

R E M A R K S

Reconsideration of this application, as amended, is respectfully requested.

ALLOWABLE SUBJECT MATTER

The Examiner's allowance of claims 1 and 4-13, and the Examiner's indication of the allowability of the subject matter of claims 2-3, 14-31 and 37-38 are respectfully acknowledged.

Claims 1-31 and 37-38 have been amended to only to make minor grammatical improvements and/or to correct minor antecedent basis problems so as to put the claims in better form for allowance in a U.S. patent. All of the minor informalities pointed out by the Examiner have been corrected.

Submitted herewith are copies of the original claims marked to show the changes made, and clean versions of the amended claims are set forth hereinabove.

No new matter has been added, and no new issues with respect to patentability have been raised. Accordingly, it is respectfully requested that the amendments to the claims be approved and entered, and it is respectfully submitted that the amended claims are in condition for immediate allowance.

It is respectfully submitted, moreover, that the amendments to the claims are clearly clerical in nature and are not related to patentability and do not narrow the scope of the claims either literally or under the doctrine of equivalents.

THE SPECIFICATION

The specification has been amended to some correct minor informalities of which the undersigned has become aware, including all of the informalities pointed out by the Examiner.

Submitted herewith are marked copies of the changed pages to show the changes made, and full replacement paragraphs are set forth hereinabove.

No new matter has been added, and it is respectfully requested that the amendments to the specification be approved and entered, and that the objection to the specification be withdrawn.

* * * * *

In view of the foregoing, entry of this Amendment, allowance of the claims and the passing of this application to issue are respectfully solicited.

If the Examiner has any comments, questions, objections or recommendations, the Examiner is invited to telephone the undersigned for prompt action.

Respectfully submitted,



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COOLER FOR ELECTRONIC DEVICES

FIELD OF THE INVENTION

The present invention relates generally to cooling devices and, more particularly, to cooling devices for removing heat from electronic devices by a flow of gas, in particular, airflow, said flow being produced by a blower.

BACKGROUND OF THE INVENTION

During normal operation, most of electronic devices generate significant amounts of heat. If this heat is not continuously removed, the electronic device may overheat, resulting in damage to the device and/or a reduction in operating performance.

In order to avoid such problems caused by overheating, cooling devices are often used in conjunction with electronic devices.

One such cooling device used in conjunction with electronic devices is a fan assisted heat sink. In such device, a heat sink is formed from a material, such as aluminum, which readily conducts heat. The heat sink is usually placed on top of, and in physical contact with, the electronic device.

One method of increasing the cooling capacity of these heat sinks is by including a plurality of cooling fins that are physically connected to the heat sink. These fins serve to increase the surface area of the heat sink and, thus, maximize the transfer of heat from the heat sink to the ambient air. In this manner, the heat sink draws heat away from the electronic device and transfers the heat to the ambient air.

In order to further enhance the cooling capacity of a heat sink device, an electrically powered blower (an axial fan may serve as the blower) is often mounted within or on top of the heat sink. In operation, the fan forces air to pass over the fins of the heat sink, thus, cooling the fins by enhancing the heat transfer from the fins into the ambient air. As the fins are cooled, heat can be drawn from the electronic device and into the heat sink at a faster rate. The fan typically draws air into the heat sink from the top of the heat sink, passes the air over the fins, and

exhausts the air from the heat sink in the vicinity of the bottom (side) of the heat sink. Accordingly, the exhaust air is hotter than the intake air.

There are known devices of this type - see, for example, US patent № 5867365 "CPU heat sink assembly" and US patent № 5661638 "High performance spiral heat sink".

The design of the device described in US patent № 5867365 comprises an axial fan that produces a flow passing by heat exchanging channels of the heat sink. The majority of inlets to heat exchanging channels are located just opposite the axial fan's impeller with a certain number of said channels being placed radially in relation to fan axle.

US patent № 5661638 also involves the application of an axial fan. Specific embodiment of device claimed in said patent involves such placement of heat exchanging channels of the heat sink that they are located centrally-symmetrically about the fan axle. To increase the heat exchange area, the heat exchanging channels are made of spiral-like shape and bent backwards in the direction of blower rotation. In this case the fan is installed in a recess made in the heat sink body.

In the above-mentioned designs, the axial fan produces sufficient air pressure. However, due to the weak airflow in the area adjacent to the fan axle, the conditions for cooling the central part of the heat sink, located underneath the fan, are unfavorable. In this case uniform cooling of the heat sink and electronic device, ^{such as} ~~for example~~, processor, will not take place. The energy of airflow outgoing from fan impeller, in the axial direction, is expended on deceleration and change in flow direction before entering to the heat exchanging channels. This decreased airflow velocity, passing by the heat exchanging channels doesn't allow good conditions for the heat exchange process.

Centrifugal blowers are rarely used in cooling device designs for the purpose of producing airflow.

Specifically, US patent № 5838066 "Miniaturized cooling fan type heat sink for semiconductor device" offers a design employing a centrifugal blower that is installed to the side of the heat sink. In one particular embodiment of this invention the cooling airflow passes by rectilinear heat exchanging channels of the heat sink.

However, placement of the centrifugal blower to the side of the heat sink increases the device size. The location of the centrifugal blower leads to poor coordination between the airflow produced by the blower and the direction of the inlet channels of the heat sink. The loss

in airflow energy results in the reduction of airflow speed in the heat exchanging channels and in the decline of heat exchange efficiency. A portion of energy, of the airflow, is also expended in the form of friction against the casing enclosing the blower.

An invention described in the patent of Japan № 8-195456 entitled "Cooler for electronic apparatus". This device comprises a centrifugal fan enclosed in the casing and installed above the heat exchanging channels that are made divergent. Another heat sink surface is made so that the possibility of thermal contact with an electronic device is provided for. The inlet of the centrifugal fan faces the heat sink. The fan produces an airflow that passes by heat exchanging channels and then gets drawn into the inlet of the centrifugal fan. Since the centrifugal fan operates by drawing air in to the heat sink, there is an area in the central part of the heat sink that receives poor airflow movement. This can be seen in the published patent. Therefore, cooling of the heat sink's central part, which is the hottest, is ineffectively performed and results in uneven cooling of the heat sink. To avoid uneven cooling of the heat sink, one has to raise the fan power in order to increase the airflow. In addition, the device is of considerable height because of the centrifugal fans placement above the heat sink, and the electric drives placement above the centrifugal fan.

Increasing the size of the cooling device in a vertical direction (i.e. in a direction transverse to the orientation of the integrated circuit device) is often a problem because of the limited envelope available in many applications, such as in the computer case of a desktop computer and especially for portable electronic devices such as laptop computers. This is an even greater problem because, in most situations, a fairly substantial clearance area is required between the fan opening and the computer case to allow adequate airflow into or out of the fan.

Thus, it would be generally desirable to provide an apparatus, which overcomes these problems associated with fan assisted heat sink devices.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a cooler that achieves more uniform cooling of electronic devices by more effective cooling of the central part of the heat exchange element.

As describe above the electric drive 4 is a flat rotor type DC brushless motor. The motor gains a rotation torque attributed to an interaction between a magnetic field produced by many-poles magnetized rotor 16 and magnetic field produced by exciting coils 25 of the stator 17 so as to be rotated in one direction. The stator coils 25 cores is connected with a controller 66, for example of type Fairchild NDS8858H.

The rotor 16 of the electric drive 4 comprising two disks mounted on a shaft with poles distributed over the outer circumference and a cylindrical magnet located between the disks and magnetized in the axial direction, in a such manner that the poles of each disk are the like ones, and in regard to the poles of the other disk - the unlike ones, the stator being made of coils distributed over the circumference, while in accordance with the invention the rotor poles are formed by the teeth located over the outer circumference of both disks in planes perpendicular to the axis of the device, and the poles of the stator coils are arranged in a such way as to allow for their end-face interaction with the rotor poles.

The rotor poles are formed by the teeth located over the outer circumference of both disks, which function as magnetic circuits. This ^{enables} ensures streamlined manufacturing of the rotor and ^{achieves strong} its structural strength. Owing to the fact that the rotor poles are located over the outer circumference of both disks in planes perpendicular to the axis of the device, and the poles of the stator are arranged in a such way as to allow for their end-face interaction with the rotor poles, there arises an opportunity to make the radial size of the device smaller.

As a particular example, the stator poles may be located in the space between the above-mentioned rotor poles outfitted on both disks. This will make it possible to raise the power of the drive, as the magnetic field in the space between the rotor poles will have the highest intensity.

The rotor disks, one or both of them, may be made as flat disks with teeth – poles over the outer circumference, and in this case the rotor poles will be in the same plane with the respective disk, or they may have a plate-like shape. This permits one to obtain the device of the optimum size in dependence of the magnet used, stator, rotor, the required power, and the size of the equipment where the electric drive is supposed to be installed.

Independence of the stator design the rotor poles of one disk may be located in the axial direction both opposite the rotor poles of the other disk, or between them. Taking in view the fact that the operating principle of such devices is based on alternate switching of the stator coils distributed over the circumference, whose magnetic field interacts with the rotor poles, this latter

What is claimed is:

1. A cooler for electronic devices comprising

(i) a heat exchange element having a first and a second surfaces, a blower with a radial type impeller, and an electric drive, wherein:

(ii) said heat exchange element comprising heat exchanging means made on the first surface of said heat exchange element while its second surface provides thermal contact with a heat-radiating means;

(iii) said radial type impeller has a shroud with a flat surface from one side, a hub and brackets and a central inlet between the shroud and the hub, said brackets connect the hub with the shroud; said radial type impeller is positioned on the heat exchange element so that the heat exchanging means is surrounded by the radial type impeller and a cooling gas flows to the radial type impeller from the central inlet through the heat exchanging means;

(iv) said electric drive comprising a magnetic rotor and a stator; said magnetic rotor is a substantially flat disk rotor comprising a central hole inside the substantially flat disk rotor and circumferential arrayed like poles, said stator comprising circumferential arrayed coils whose axes are parallel to the axis of rotation, said coils mounted around the circumferential arrayed like poles; said magnetic rotor is placed on the shroud of the radial type impeller and connect with the shroud, the shaft of the electric drive is located inside the hub of the radial type impeller, and the central hole of the flat disk rotor is substantially coincided with the central inlet.

2. A cooler for electronic devices as claimed in claim 1, wherein said substantially

a. flat disk rotor further comprising at least two magnetized rings having the central hole inside the rings and circumferential arrayed like poles and being mounted perpendicularly to the axis of rotation, and said circumferential arrayed like poles of one of the magnetized rings being magnetized in opposite polarity and coincide to the circumferential arrayed like poles of another magnetized ring in a projection at a plane normal to the axis of rotation, said at least two flat rings installed with a gap between said flat rings in a place where the magnetic rotor interact with the stator and with a contact between said flat ring axially beyond the gap, and wherein said coils of said stator at least partially mounted at the gap between the circumferential

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arrayed like poles of one of the magnetized ring^s and the like circumferential arrayed like poles of the another adjacent magnetized ring.

3. A cooler for electronic devices as claimed in claim 2, further including a cylindrical magnet, said cylindrical magnet being magnetized in the axial direction and placed coaxially to the shaft between said magnetized disks.

4. A cooler for electronic devices as claimed in claim 1, wherein the heat exchanging means ~~are~~ pins and fins.

5. A cooler for electronic devices as claimed in claim 1, wherein the heat-radiating means ~~is~~ the electronic device.

6. A cooler for electronic devices as claimed in claim 1, wherein the heat-exchange element ~~is made from~~ comprises a high heat-conducting material.

7. A cooler for electronic devices as claimed in claim 1, wherein the heat-radiating means ~~is~~ a heat-pipe.

8. A cooler for electronic devices as claimed in claim 1, wherein the brackets ~~are~~ comprise axial blower blades.

9. A cooler for electronic devices as claimed in claim 1, wherein one of the flat rings of the magnetic rotor is placed flush-mounted with the flat surface of one side of the shroud of the radial type impeller.

10. A cooler for electronic devices as claimed in claim 1, wherein the flat rings are magnetized in such way that the poles of each flat rings are like poles, while in relation to the poles of another flat rings they are unlike poles, the magnetic rotor poles ~~are made up by~~ comprise teeth on the outer circumferences of said flat rings, ~~and~~ said teeth coincide along the direction of said rotation axis.

11. A cooler for electronic devices as claimed in claim 1, wherein the radial type impeller ~~is~~ a drum type impeller.

12. A cooler for electronic devices as claimed in claim 1, wherein the radial type impeller ~~is~~ a disk-type impeller, ~~said disk type impeller comprising~~ at least one disk.

13. A cooler for electronic devices as claimed in claim 1, wherein the stator poles are placed in the space between the said magnetic rotor poles ~~made on both disks~~.

14. A cooler for electronic devices comprising:

(i) a heat exchange element having a first ^{surface} and a second ^{surface}, a blower with a radial type impeller and an electric drive, wherein:

(ii) said heat exchange element ^{comprises} has heat exchanging means and heat exchanging channels made on the first surface of said heat exchange element while its second surface provides thermal contact with a heat-radiating means;

(iii) said radial type impeller ^{comprises} comprising a shroud with a flat surface from one side, a hub, brackets, and a central inlet between the shroud and the hub, said brackets ^{connecting} connect the hub with the shroud;

(iv) said heat exchanging means ^{is} surrounded by the radial type impeller, said radial type impeller ^{is} surrounded by said heat exchanging channels, and a cooling gas flows from the central inlet through the heat exchanging means, the radial type impeller and the heat exchanging channels in a series way;

(v) said electric drive ^{comprises} comprising a magnetic rotor and a stator, said magnetic rotor comprising at least two magnetized ^{flat} rings having a hole inside said rings and circumferential arrayed like poles and being mounted perpendicularly to the axis of rotation, and said circumferential arrayed like poles of one of the magnetized ring ^s being magnetized in opposite polarity and coincide to the circumferential arrayed like poles of another magnetized ring ^s in a projection at a plane normal to the axis of rotation, said at least two flat rings ^{are} installed with a gap between said flat rings in a place where the magnetic rotor interact with the stator ^{wherein} and with a contact ^{is provided} between said flat ring axially beyond the gap, said stator ^{comprises} comprising circumferential arrayed coils, ^{whose axes} axis of said coils are parallel to the axis of rotation, said coils ^{being} at least partially mounted at the gap between the circumferential arrayed like poles of one of the magnetized ring ^s and the like circumferential arrayed ^{the} poles of the ^{second one of} adjacent magnetized ring ^s, and wherein one of the flat rings of said magnetic rotor is placed on the shroud of the radial type impeller, a shaft of the electric drive is located inside the hub of the radial type impeller, and the hole inside the rings ^{is} substantially coincided with the central inlet.

15. A cooler for electronic devices as claimed in claim 14, wherein the heat exchanging means are pins and/or fins.

16. A cooler for electronic devices as claimed in claim 14, wherein the heat exchanging channels are formed by rows of profiled elements.

17. A cooler for electronic devices as claimed in claim 16, wherein said profiled elements comprising pins and/or fins.

18. A cooler for electronic devices as claimed in claim 14, wherein the heat exchanging channels are made spiral-like and bent in the direction of blower rotation.

19. A cooler for electronic devices as claimed in claim 14, wherein inlets of the heat exchanging channels are oriented in the direction of propagation of an output of the cooling gas flow produced by the radial type impeller.

20. A cooler for electronic devices as claimed in claim 14, wherein the heat exchanging channels have a constant width.

21. A cooler for electronic devices as claimed in claim 14, wherein the heat radiating means is an electronic device.

22. A cooler for electronic devices as claimed in claim 14, wherein the heat exchanging means is made from a high heat-conducting material.

23. A cooler for electronic devices as claimed in claim 14, wherein the heat radiating means is a heat-pipe.

24. A cooler for electronic devices as claimed in claim 14, wherein the brackets are axial blower blades.

25. A cooler for electronic devices as claimed in claim 14, wherein one of the flat rings of the magnetic rotor is placed flush-mounted with the flat surface of one side of the shroud of the radial type impeller.

26. A cooler for electronic devices as claimed in claim 14, wherein the flat rings are magnetized in a such way that the poles of each flat ring are like poles, while in relation to the poles of another flat ring they are unlike poles, the magnetic rotor poles are made up by teeth on the outer circumferences of said flat rings.

27. A cooler for electronic devices as claimed in claim 14, further including a cylindrical magnet, said cylindrical magnet being magnetized in the axial direction and placed coaxially to the shaft between said magnetized disks.

28. A cooler for electronic devices as claimed in claim 14, wherein the radial type impeller is a drum type impeller.

29. A cooler for electronic devices as claimed in claim 14, wherein the radial type impeller is disk type impeller, said disk type impeller comprising at least one disk.

30. A cooler for electronic devices as claimed in claim 14, wherein the stator is being comprised of a printed circuit board, said printed circuit board covers the heat exchanging channels from the opposite side of the surface which provides thermal contact with the heat-radiating means.

31. A cooler for electronic devices as claimed in claim 14, wherein the stator poles are placed in the space between the said magnetic rotor poles made on both disks.

32. An electric drive for cooler for electronic device comprising a stator, a magnetic rotor and a motor controller, wherein; said magnetic rotor comprising at least two magnetized rings having circumferential arrayed like poles and being mounted perpendicularly to the axis of rotation, and said circumferential arrayed like poles of one of the magnetized ring being magnetized in opposite polarity and coincide to the circumferential arrayed like poles of another magnetized ring in a projection at a plane normal to the axis of rotation said at least two flat rings installed with a gap between said flat rings in a place, where the magnetic rotor interact with the stator and with a contact between said flat ring axially beyond the gap, said rotor having a hole inside the two magnetized rings; said stator comprising circumferential arrayed coils, axis of said coils are parallel to the axis of rotation, said coils at least partially mounted at the gap between the circumferential arrayed like poles of one of the magnetized ring and the like circumferential arrayed poles of the another adjacent magnetized ring; one of the flat rings of said magnetic rotor is placed on an annular flat disk made from nonmagnetic material, said annular flat disk being connected by brackets with a shaft of the electric drive, and an area inside said annular flat disk is coincided with the hole.

33. An electric drive for cooler for electronic devices as claimed in claim 32, wherein the brackets are made in the form of axial blower blades.

34. An electric drive for cooler for electronic devices as claimed in claim 32, wherein the flat rings are magnetized in a such way that the poles of each flat rings are like poles, while in relation to the poles of another flat rings they are unlike poles, the magnetic rotor poles are made up by teeth on the outer circumferences of said flat rings.

35. An electric drive for cooler for electronic devices as claimed in claim 32, further including a cylindrical magnet, said cylindrical magnet being magnetized in the axial direction and placed coaxially to the shaft between said magnetized disks.

36. An electric drive for cooler for electronic devices as claimed in claim 32, wherein the stator being made like printed circuit board.

37. A cooler for electronic devices comprising at least two heat exchange elements, each of said heat exchange elements having ^{surface} ^{surface} ^{having} a first and a second surfaces, a blower with a radial type impeller, ^{a heat radiating means}, and an electric drive, wherein ^{R (ii) can't} ^{comprise} ^{provided} ^{part of} ^{the} said heat exchange element comprising heat exchanging means ^{made} on the first surface of said heat exchange element while its second surface ^{provides thermal contact with a heat-radiating means}; ⁽ⁱⁱⁱ⁾ ^{comprises} ^{having} ^{on} ^{and wherein} ^{R (ii) COMPARTE} said radial type impeller has two shrouds, each of said shrouds ^{having} ^{on} a flat surface from one side, a hub and a central inlet between the shroud and the hub, ^{and wherein} ^{R (ii)} ^{COMPARTE} said radial type impeller is positioned on the heat exchange element so that a cooling gas flows from the central inlet through the radial type impeller and the heat exchanging means in ^{a series way}, ^{comprising} ^{being} ^{an} ^{axis} ^{axis of said coils} said electric drive comprising a magnetic rotor and a stator, ^{being} ^{an} ^{axis} ^{whose axes} said magnetic rotor is a substantially flat disk rotor comprising circumferential arrayed like poles, ^{and} ^{being} ^{an} ^{axis} ^{axis of said coils} said stator comprising circumferential arrayed coils ^{are} parallel to the axis of rotation, ^{wherein} ^{being} ^{an} ^{axis} ^{axis of said coils} mounted around the circumferential arrayed like poles, ^{wherein} ^{being} ^{an} ^{axis} ^{axis of said coils} said magnetic rotor is placed on the shrouds of the radial type impeller and connects with the shrouds, the shaft of the electric drive is located inside the hub of the radial type impeller, ^{and} ^{being} ^{an} ^{axis} ^{axis of said coils} said substantially flat disk rotor further comprising at least two magnetized rings ^{are} circumferential arrayed like poles and being mounted perpendicularly to the axis of rotation, ^{and} ^{being} ^{an} ^{axis} ^{axis of said coils} and said circumferential arrayed like poles off one of the magnetized ring ^{is} being magnetized in opposite polarity and coincide to the circumferential arrayed like poles of another magnetized ring in a projection at a plane normal to the axis of rotation, ^{wherein} ^{being} ^{an} ^{axis} ^{axis of said coils} said at least two flat rings installed with a gap between said flat rings in a place where the magnetic rotor interact with the stator and with a contact ^{between} ^{is provided} ^{and} ^{being} ^{an} ^{axis} ^{axis of said coils} between said flat ring axially beyond the gap, ^{and} ^{being} ^{an} ^{axis} ^{axis of said coils} said coils of said stator at least partially mounted at the gap between the circumferential arrayed like poles of one of the magnetized ring ^{like} ^{second one of the} ^{comprise} and the like circumferential arrayed poles of the another adjacent magnetized ring, ^{and} ^{being} ^{an} ^{axis} ^{axis of said coils} and wherein said heat radiating means is at least one heat pipe ^{and} ^{being} ^{an} ^{axis} ^{axis of said coils} at least one heat pipe is in contact with two second surfaces of said at least two heat exchange elements.

38. A cooler for electronic devices comprising:

(i) a heat exchange element having a first ^{surface} and a second surfaces, a blower with a radial type impeller, a heat radiating means and an electric drive, wherein ^{R (ii)} said heat exchange

Comprises
element has heat exchanging means made on the first surface of said heat exchange element;
~~comprising~~
R(iii) said radial type impeller comprising at least two shroud each of said at least two shroud ~~has~~ having
a flat surface from one side, work elements from another side, a hub, ~~brackets~~ and a
central inlet between the work elements and the hub, said shrouds ^{being} connected with the hub, and wherein
said radial type impeller being surrounded by said heat exchanging means and a cooling gas
flows from the central inlet through the radial type impeller and the heat exchanging means
in a series way, ^{R(iv)} said electric drive comprising a magnetic rotor and a stator, said magnetic
rotor comprising at least two magnetized rings having circumferential arrayed like poles and
being mounted perpendicularly to the axis of rotation, and said circumferential arrayed like
poles of ^{a first} one of the magnetized ring being magnetized in opposite polarity to the
circumferential arrayed like poles of ^{a second one of the} another magnetized ring in a projection at a plane
normal to the axis of rotation, said at least two flat rings installed with a gap between said flat
rings in a place where the magnetic rotor interact with the stator and with a contact between
said flat ring axially beyond the gap, said stator comprising circumferential arrayed coils,
whose axes are parallel to the axis of rotation, said coils at least partially mounted at the
gap between the circumferential arrayed like poles of one of the magnetized ring and the like
circumferential arrayed poles of the another adjacent magnetized ring, wherein each of the flat
rings of said magnetic rotor is placed on the flat surface of the everyone of the at least two
shroud of the radial type impeller and connect with them, a shaft of the electric drive is
located inside the hub of the radial type impeller, and wherein said stator is located on a flat
plate, said flat plate connects with the heat exchanging means, and the heat-radiating means
is located between the heat exchanging means.